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AUTHOR	Johnson, David J.
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ABSTRACT

The first of a two-part sequence for the student who has had difficulty in second-year algebra, this booklet covers definitions and measurement of angles (in degrees and radians), the trigonometric functions, solving trigonometric equations and graphing functions, identities, and computation with base ten logarithms. Overall goals for the course are stated and performance objectives for each unit are specified. A course outline, references to state-adopted texts, and teaching suggestions are listed. Included are sample pretests and posttests and an annotated list of five references. For the other booklet in this sequence, see SE 014 900. (DT)

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AUTHORIZED COURSE OF INSTRUCTION FOR THE QUINMESTER PROGRAM

DADE COUNTY PUBLIC SCHOOLS

TRIGONOMETRY 1

5219.11

MATHEMATICS

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QUINMESTER MATHEMATICS

COURSE OF STUDY

FOR

TRIGONOMETRY 1

5219.11

(EXPERIMENTAL)

Written by

David J. Johnson

for the

DIVISION OF INSTRUCTION
Dade County Public Schools
Miami, Florida 33132
1971-72

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PREFACE

The following course of study has been designed to set a minimum standard for student performance after exposure to the material described and to specify sources which can be the basis for the planning of daily activities by the teacher. There has been no attempt to prescribe teaching strategies; those strategies listed are merely suggestions which have proved successful at some time for some class.

The course sequence is suggested as a guide; an individual teacher should feel free to rearrange the sequence whenever other alternatives seem more desirable. Since the course content represents a minimum, a teacher should feel free to add to the content specified.

Any comments and/or suggestions which will help to improve the existing curriculum will be appreciated. Please direct your remarks to the Consultant for Mathematics.

All courses of study have been edited by a subcommittee of the Mathematics Advisory Committee.

CATALOGUE DESCRIPTION

The first of a two - quin sequence designed for the serious student who has encountered difficulty in second year Algebra. An introduction to trigonometric functions of angles in standard position. Includes radian measure, angular velocity, fundamental identities, linear and quadratic trigonometric equations.

Designed for the student who has mastered the skills and concepts of Algebra 2 p, q, r, s, t, and/or recommendations of instructor.

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OVERALL GOALS

I. The student should learn about angles and how to measure them in degrees or radians.

II. The student should become familiar with the trigonometric functions and how to determine the functional values of a given angle.

III. The student should become familiar with solving and graphing simple trigonometric functions.

IV. The student should become familiar with the fundamental trigonometric identities and how those are used to prove other elementary trigonometric identities.

V. The student should learn multiplication and division computations by use of the common logarithm.

KEY TO STATE ADOPTED TEXTS

FOR

TRIGONOMETRY 1

D(II) Dolciani, Mary P.; Wooten, William; Beckenbach, Edwin F.; and Sharron, Sidney; Modern School Mathematics, Algebra 2 and Trigonometry; Atlanta; Houghton Mifflin Company, 1968.

DRO Drooyan, Irving and Hadel, Walter; Trigonometry, An Analytic Approach; New York; The Macmillan Company, 1967.

PA(II) Pearson, Helen R. and Allen, Frank B.; Book Two, Modern Algebra, A Logical Approach, Including Trigonometry; Boston; Gin and Company, 1966.

WOO Wooten, William; Beckenbach, Edwin F.; and Dolciani, Mary P.; Modern Trigonometry; Atlanta; Houghton Mifflin Company, 1966.

PERFORMANCE OBJECTIVES

The student will:

I. 1. Define an angle.

2. Designate an angle; its initial side and terminal side.

3. State in which quadrant an angle terminates when placed in standard position.

4. Measure a given angle:
   a. in degree measure by use of a protractor.
   b. in radian measure.

5. Change from degree to radian measure and conversely.

6. Approximate rational values for arc lengths of circles.

7. Determine the average angular velocity in radians of a particle in a circular movement and the approximate linear velocity of the same particles as a rational value.

II. 1. Define the following:

   a. sine function
   b. cosine function
   c. tangent function
   d. cotangent function
   e. secant function
   f. cosecant function
   g. circular functions
   h. periodic functions

2. Designate pairs of co-functions and pairs of reciprocal functions.

3. Determine the six trigonometric functional values of any given angle.

4. Determine each of the six (6) functional values of an angle when the coordinates of a point on the terminal side of the angle are given.

5. Know the real number values for each of the 6 functions for each of the following angles:

   a. 0° or 0^R
   c. 45° or $\frac{\pi^R}{4}$
   e. 90° or $\frac{\pi^R}{2}$
   b. 30° or $\frac{\pi^R}{6}$
   d. 60° or $\frac{\pi^R}{3}$
   f. 180° or π^R

6. Determine the reference angle for any angle larger than 90°.

7. Approximate to the nearest thousandth the rational value of any trigonometric function of any given angle to the nearest minute by using tables and interpolation.

8. Approximate to the nearest minute, the measure of an angle when given a functional value of that angle by using tables.

III. 1. Solve both of the following types of trigonometric equations:

   a. equations in one variable that involve no more than one trigonometric function.
   b. equations in one variable that involve expressions of two or more trigonometric functions that can be transformed into an expression of only one trigonometric function.

2. Graph the 6 trigonometric functions and identify the graphs of each.

3. Graph $y = c + a \sin(bx + d)$ where a, b, c, and d, are constants for sine, cosine, and tangent functions and shall be able to state the following about the graph without graphing:

   a. maximum functional value.
   b. minimum functional value.
   c. amplitude.
   d. the fundamental period.

IV. 1. Know these eight fundamental trigonometric identities:

   a. $\sin^2 a + \cos^2 a = 1$

   b. $\tan a = \frac{\sin a}{\cos a}$, $\cos a \neq 0$

c. $\cot a = \frac{\cos a}{\sin a}$, $\sin a \neq 0$

d. $\sec a = \frac{1}{\cos a}$, $\cos a \neq 0$

e. $\csc a = \frac{1}{\sin a}$, $\sin a \neq 0$

f. $\tan a = \frac{1}{\cot a}$, $\tan a \neq 0$, $\cot a \neq 0$

g. $\tan^2 a + 1 = \sec^2 a$, $\cos a \neq 0$

h. $1 + \cot^2 a = \csc^2 a$, $\sin a \neq 0$

2. Prove some elementary trigonometric identities particularly for the purpose of solving trigonometric equations.

V. 1. Write the scientific or standard notation for any decimal numeral.

2. Determine, with the use of a table, the log of any decimal numeral of no more than three significant digits.

3. Determine the antilog of any numeral, of no more than four decimal places, that is greater than -10 but less than ten.

4. Simplify any expression that involves the operations of multiplication and/or division and numerals of no more than three significant digits by the use of common logarithms.

COURSE OUTLINE

I. Angles

A. Definitions about Angles:

1. vertex
2. sides
   (a) initial side
   (b) terminal side
3. coterminal angles
4. standard position
5. right angles
6. straight angles
7. directed angles

B. Measurement of Angles:

1. degree measurement:
   (a) using the protractor to measure angles
   (b) positive angles
   (c) negative angles
2. radian measure
   (a) the unit circle
   (b) definition of radians
   (c) conversion equations

   (1) $1^\circ = \frac{\pi}{180}$ radian

   (2) 1 radian = $\frac{180^\circ}{\pi}$

   (d) determining arc lengths
   (e) determining angular velocity

II. The Trigonometric Functions

A. Definitions

1. sine
2. cosine
3. tangent
4. reciprocal functions
   (a) secant
   (b) cosecant
   (c) cotangent
5. co-functions
6. circular functions
7. periodic functions
8. reference angles

B. Determining the functional values of angles.

1. using the Pythagorean Theorem to determine the value of an acute angle.
2. using reference angles to determine functional value of larger angles.
3. using tables to approximate rational functional values.
   (a) for angles greater than or equal to $0°$ and less than or equal to $90°$.
   (b) using reference angles for angles greater than $90°$.
   (c) using linear interpolation for angles involving minute measurement not found in tables.

III. Trigonometric Functions and their Graphs

A. Solving Trigonometric Equations

1. definition of a trigonometric equation.
2. the nature of the solution set of a periodic or circular function.

B. Graphing a Trigonometric Function

1. definitions:
   (a) maximum value
   (b) minimum value
   (c) amplitude
   (d) fundamental period
2. graphing the basic functions
   (a) $y = \sin x$
   (b) $y = \cos x$
   (c) $y = \tan x$
   (d) $y = \csc x$
   (e) $y = \sec x$
   (f) $y = \tan x$
3. graphing more general trigonometric functions:
   (a) $y = a \sin x$
   (b) $y = \sin bx$
   (c) $y = c + \sin x$
   (d) $y = \sin (x + d)$
   (e) $y = c + a \sin (bx + d)$
   (f) observing the effects of constants on cosine and tangent graphs

IV. Trigonometric Identities

A. The fundamental trigonometric identities.

B. Proving trigonometric identities:

1. stating a given trigonometry expression in terms of a given trigonometric function.
2. prove procedures.
3. proving identities using the fundamental identities.

V. Reviewing Computation with Base Ten Logs

A. Understanding the base ten log tables:

1. representing numbers by scientific notation.
2. representing numbers by powers of ten.
3. laws for computation by logs.
   (a) $x^a \cdot x^b = x^{a+b}$
   (b) $\frac{x^a}{x^b} = x^{a-b}$
   (c) $(x^a)^b = x^{a \cdot b}$

B. Using the base ten log tables.

1. definitions
   (a) common logarithms
   (b) mantissa
   (c) characteristic
   (d) antilogarithm
2. determining the logarithm and antilogarithm using common log tables.
3. interpolating for a better approximation

C. Computation by use of common logarithms:

1. computing products ($\log ab = \log a + \log b$).
2. computing quotients ($\log \frac{a}{b} = \log a - \log b$).

REFERENCES

OUTLINE	TOPIC	TEXT	DAYS
I A,B	Angles and Their Measurements	D(II); ch 11, pp. 481-489 Dro; ch 4, pp 122-133 P(II); ch 9, pp 449-467 Woo; ch 1, pp 29-37 ch 5, pp 163-168	5
II A	Trigonometric Functions	D(II); ch 11, pp 490-494 pp 512-517 Dro; ch 2, pp 39-51, 63-75 ch 4, pp 133-139 P(II); ch 9, pp 452-455 pp 467-474 Woo; ch 2, pp 43-50 pp 78-85 ch 5, pp 168-171	2
II B	Functional Values of Angles	D(II); ch 11, pp 495-506 pp 512-517 Dro; ch 2, pp 75-84 ch 4, pp 140-144 P(II); ch 9, pp 475-488 pp 494-499 Woo; ch 2, pp 50-55 pp 74-78 pp 175-184	8
III A	Solving Trigonometric equations	D(II); ch 13, pp 576-579 Dro; (No reference except involving identities and briefly in previous section) P(II); ch 10, pp 578-584 Woo; ch 4, pp 154-157 ch 5, pp 184-187	5
III B	Graphing Trigonometric Functions	D(II); ch 11, pp 506-517 Dro; ch 3, pp 88-121 P(II); ch 10, pp 556-568 Woo; ch 3, pp 96-129	8

OUTLINE	TOPIC	TEXT	DAYS
IV A,B	Trigonometric Identities	D(II); ch 9, pp 407-419 Dro; ch 4, pp 148-152 P(II); ch 10, pp 531-541 Woo; ch 2, pp 56-74 pp 78-90 ch 5, pp 172-175	5
V A,B	The Common Logarithms	D(II); ch 9, pp 407-419 Dro; App. A, pp 269-273 P(II); ch 8, pp 396-398 pp 417-433 Woo; Appendix A, pp. 368-374	4
V C	Computations using Common Logarithms	D(II), ch 9 pp 419-430 Dro; Appendix A, pp 273-281 P(II); ch 8, pp 433-437 Woo; Appendix A, pp 374-376	3

SUGGESTED STRATEGIES

1. The "D" text makes no particular reference to angular velocity but there are related problems found in the "Written Exercises" on page 485. The particular topic is found in "P" on pages 465 and 466.

2. In III of the outline and objectives, it should be noted that III A, 2 objective (solving equations that require substitution of a trigonometric identity) could only be taught after identities have been introduced. Thus solving this type of trigonometric equation must be considered later.

3. It should be considered that the student should be able to graph $y = \sin x$, $y = \cos x$, and $y = \tan x$ from memory and that he know the effects of each constant in $y = c + a \sin (bx + d)$ on the graph.

4. The student should be expected to know the eight identities listed in objectives IV A, from memory, but should be able to prove the last two from the preceeding.

5. In proving identities ingenuity and logic should be stressed for this level student rather than form discipline.

6. In V of the outline, the instructor should stress understanding and practical use of the common logarithm.

7. In the "D" and "P" state adopted texts, the topics are fairly well organized as the course outline, although not necessarily in the same sequences. However, the topics, as organized and defined in this course of study, are not so organized and defined in "W". In fact they are so different, that if the teacher is using "W", he may prefer to organize the course to coincide with "W" and simply check the objectives as they are met.

8. The suggested time table is organized for forty days, allowing a five day leeway for review and testing or simply loss of time for any reasons.

9. If the teacher runs short of time and feels he must delete part of the course, it is suggested that this be the units on common logarithm since many of the students will have had this in previous Algebra courses.

10. If the teacher feels that he prefers to start with something that might be familiar to the student, then the two units in common logarithms might be considered first.

SAMPLE PRE-TEST

State whether each of the following is true or false.

1. If $f(x) = (x + 3)^2$, then $f(-2) = -1$.

2. If $f(x) = 3$, $g(x) = x^2$, and $x = -\frac{1}{2}$, then $f(g(x)) = 3$.

3. The graph of $3x + 2y = 1$ passes through $(-1, 2)$ and $(3, -4)$.

4. $\{x \mid x < -10\}$ is the solution set for $-5 - 4x > 35$.

5. The line, $2x + y = 7$, is parallel to the line, $2x - y = 7$.

6. The line, $2x + y = 7$, is perpendicular to the line, $2x - y = 7$.

7. The factors of $x^3 - y^3$ are $(x + y)(x^2 - xy - y^2)$.

8. $\frac{x^0}{x^{-1}} = 0$

9. $(-3xy)(-4x^{-1})(5y^3) = -60y^4$

10. The factors of $(x^2 + 6x + 9) - y^2$ are $(x + y + 3)(x - y - 3)$.

11. $.\overline{395} = \frac{79}{200}$

12. $\frac{3}{2 - \sqrt{2}}$ in simplist form is $3 + \frac{3}{2}\sqrt{2}$.

13. $(4 + \sqrt{2})(3 + \sqrt{2}) = 14 - 7\sqrt{2}$.

14. $\sqrt{\frac{2}{3}}$ in simplist form is $\frac{1}{3}\sqrt{6}$.

15. $\frac{8}{4\sqrt{-2}}$ in simplist form is $i\sqrt{2}$.

16. The length of the segment with end points of (3,6), (-5,-7) is an irrational value.

Solve each of the following equations:

17. $3(5 + y) + y = 7$

18. $\frac{x}{x + 3} + \frac{3}{x - 3} = \frac{x^2 + 9}{x^2 - 9}$

19. $x^2 + 4x - 5 = 0$

20. $y^2 + 3y + 6 = 0$

21. $\sqrt{x^2 + x + 4} = 2$

22. $\left(\frac{1}{4}\right)^{x - 1} = 8^{2x - 1}$

Sketch the graph of each of the following:

23. $2x - 3y = 5$

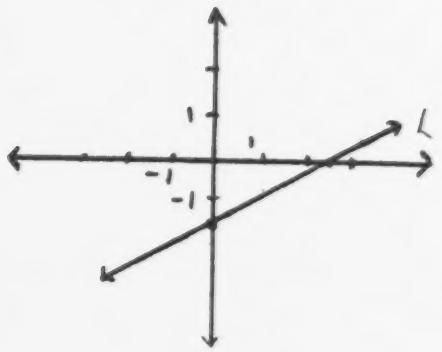
24. $y = x^2 + 2x + 1$

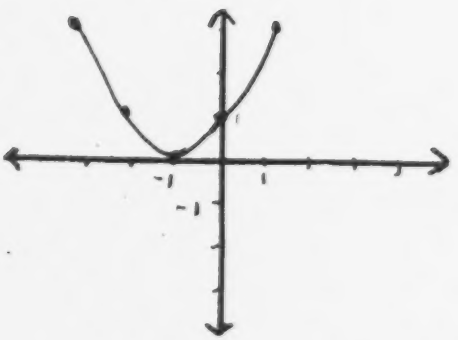
Solve the following:

25. Given the square ABCD, with diagonal BD = 10 cm; determine the area of the square ABCD.

26. Is the triangle ABC, with vertices A(3,0); B(4,1) and C(-2,6) an isosceles triangle?

ANSWER KEY

1. false
2. true
3. true
4. true
5. false
6. false
7. false
8. false
9. false
10. false
11. false
12. true
13. false
14. true
15. false
16. true
17. $\{-2\}$
18. {Real Numbers}
19. $\{-5, 1\}$
20. $\left\{\frac{-3 \pm \sqrt{15}}{2}\right\}$
21. $\{-4, 3\}$
22. $\left\{\frac{5}{8}\right\}$
23. 

24. 

25. 50 cm.^{2}
26. yes

SAMPLE POST-TEST

Objective		Test Item	
I	1. 2.	1.	Construct the following angles in standard position designating terminal and initial sides. a) 30° b) 115° c) 305° d) 180°
	3.	2.	State in which quadrant each of the preceeding angles terminates when in standard position.
	4.	3.	Measure the following angles and state in both degree and radian measure. a) b)
	5.	4.	Change the following degree measures to radian and radian measures to degree. a) 30° b) 225° c) 150° d) $\frac{\pi}{4}$ e) $\frac{23\pi}{12}$ f) $\frac{-7\pi}{6}$
	6.	5.	On a circle with a radius of 10 inches determine the length of an arc intercepted by the following central angles. a) 60° b) 3 radians
	7.	6.	What is the linear velocity in feet per minute of a point on the rim of a wheel 15 inches in diameter, turning at a rate of 10 RPM?
II	1.	7.	State each of the following using the coordinates (x,y) and r, the distance from (x,y) to (0,0). a) sine function b) cosine function c) tangent function d) cotangent function e) secant function f) cosecant function

Objective	Test Item	
2.	8.	Name the reciprocal and cofunctions for each of the following:
		a) sine b) cotangent
3. 4.	9.	Given that the $\sin\alpha = \frac{5}{13}$, determine each of the following:
		a) $\cos\alpha =$ b) $\tan\alpha =$
		c) $\csc\alpha =$ d) $\cot\alpha =$
5. 6.	10.	Determine the rational value of y in each of the following:
		a) $y = \tan 135°$ b) $y = \cot \frac{5\pi}{4}$
		c) $y = \csc 0°$
7.	11.	By using Trigonometric Function Tables determine the following values:
		a) sin 40° b) tan 85°
		c) cos 160° d) cot 200°
8.	12.	By using Trigonometric Function Tables determine the following angles:
		a) $\sin\alpha = .0873$ b) $\cot\alpha = 1.376$
		c) $\cos\alpha = .5446$
III. 1.	13.	Solve the following equations for x:
		a) $2 \tan x - 2\sqrt{3} = 0$ b) $\cos 3x = \frac{1}{2}$
2. 3.	14.	Sketch the graph of each of the following:
		a) $y = \sin x$ b) $y = \tan x$
		c) $y = 3 + \sin 2x$

Objective		Test Item	
IV.	1.	15.	Complete each of the following fundamental identities:

a) $\sin^2\alpha + (\quad) = 1$ b) $\cot\alpha = \frac{\cos\alpha}{(\quad)}$

c) $\tan^2\alpha + (\quad) = \sec^2\alpha$ d) $1 + (\quad) = \csc^2\alpha$

2. 16. Prove each of the following:

a) $\cos\alpha \tan\alpha = \sin x$

b) $\frac{\sin\alpha + \tan\alpha}{1 + \cos\alpha} = \tan x$

c) $\sin^4\alpha - \cos^4\alpha = 2\sin^2 x - 1$

d) $(1 + \csc x)(1 - \sin x) = \cot x \cos x$

V. 1. 17. Write the scientific notation for each of the following:

a) 4,278,000,000 b) .0000000897

2. 3. 18. Use table to evaluate each of the following:

a) log .00058 b) log 47,000,000

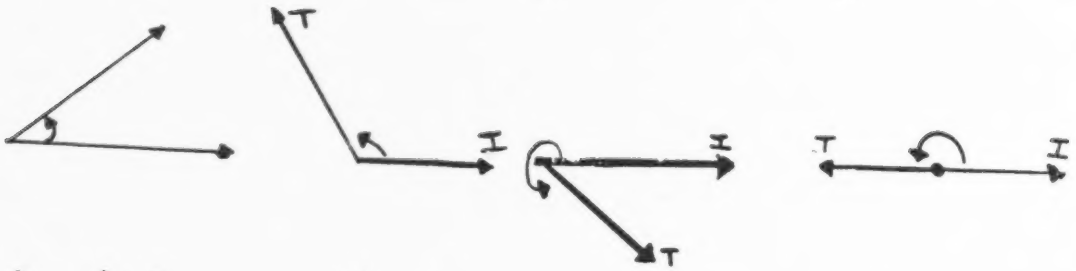
c) antilog 3.42 d) antilog 9.48 - 10

4. 19. Using tables compute the following to three significant digits:

a) $\frac{(-11.011)(.953)}{(1.72)}$ b) $\frac{.0876}{(.00596)(2,300,000)}$

POST-TEST ANSWER KEY

1. a) b) c) d)



2. a) I b) II c) IV d) X axis

3. a) $60°, \frac{\pi}{3}$ b) $245°, \frac{49\pi}{36}$

4. a) $\frac{\pi}{6}$ b) $\frac{5\pi}{4}$ c) $\frac{5\pi}{6}$

   d) $45°$ e) $345°$ f) $-210°$

5. a) 10.47 in. (app.) b) 30"

6. 39.25 ft/min.(app.)

7. a) $\frac{y}{r}$ b) $\frac{x}{r}$ c) $\frac{y}{x}$

   d) $\frac{x}{y}$ e) $\frac{r}{x}$ f) $\frac{r}{y}$

8. a) reciprocal is the cosecant
   cofunction is the cosine

   b) reciprocal is the tangent
   cofunction is the tangent

9. a) $\frac{12}{13}$ b) $\frac{5}{12}$ c) $\frac{13}{5}$ d) $\frac{12}{5}$

10. a) -1 b) 1 c) undefined

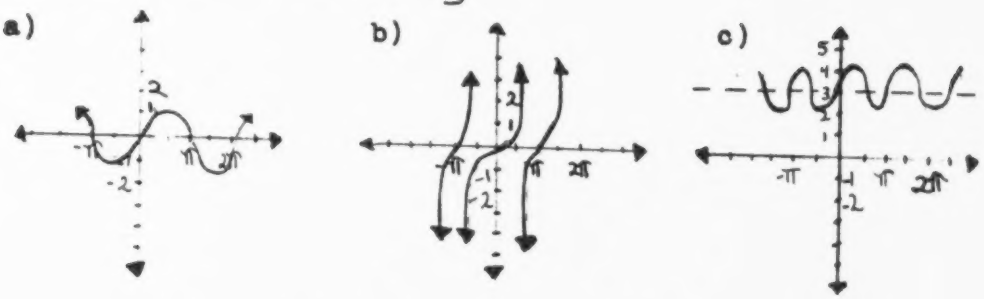
11. a) .6428 b) 11.43 c) -.9397 d) 2.747

12. a) 5° b) 36° c) 57°

13. a) $\{60°, 240°\}$ or $\left\{\frac{\pi}{3}, \frac{4\pi}{3}\right\}$

b) $\{20°, 100°, 140°, 220°\}$

14. a) b) c)



15. a) $\cos^2 \alpha$ b) $\sin \alpha$ c) 1 d) $\cot^2 \alpha$

16. a) $\cos \alpha \tan \alpha = \sin \alpha$

$$\cos \alpha \cdot \frac{\sin \alpha}{\cos \alpha} = \sin \alpha$$

$$\sin \alpha = \sin \alpha$$

b) $\dfrac{\sin \alpha + \tan \alpha}{1 + \cos \alpha} = \tan \alpha$

$$\sin \alpha + \frac{\sin \alpha}{\cos \alpha} = \frac{\sin \alpha}{\cos \alpha}(1 + \cos \alpha)$$

$$= \frac{\sin \alpha}{\cos \alpha} + \sin \alpha$$

$$= \sin \alpha + \frac{\sin \alpha}{\cos \alpha}$$

c) $\sin^4 \alpha - \cos^4 \alpha = 2 \sin^2 \alpha - 1$

$$(\sin^2 \alpha)^2 - (\cos^2 \alpha)^2 + 2 \sin^2 \alpha - 1$$

$$(\sin^2 \alpha)^2 - (1 - \sin^2 \alpha)^2 = 2 \sin^2 \alpha - 1$$

$$(\sin^2 \alpha)^2 - 1 + 2 \sin^2 \alpha - (\sin^2 \alpha)^2 = 2 \sin^2 \alpha - 1$$

$$2 \sin^2 \alpha - 1 = 2 \sin^2 \alpha - 1$$

d) $(1 + \csc\alpha)(1 - \sin\alpha) = \cot\alpha\cos\alpha$

$1 - \sin\alpha + \csc\alpha - \sin\alpha\csc\alpha = \frac{\cos\alpha}{\sin\alpha}\cos\alpha$

$1 - \sin\alpha + \frac{1}{\sin\alpha} - 1 = \frac{\cos^2\alpha}{\sin\alpha}$

$\frac{-\sin^2\alpha}{\sin\alpha} + \frac{1}{\sin\alpha} = \frac{\cos^2\alpha}{\sin\alpha}$

$1 - \sin^2\alpha = \cos^2\alpha$

$\cos^2\alpha = \cos^2\alpha$

17. a) 4.278×10^9 b) 8.97×10^{-8}

18. a) $6.7634 - 10$ b) 7.6721

c) 2,600 d) .3

19. a) 6100 b) .00000639

ANNOTATED BIBLIOGRAPHY

FOR

TRIGONOMETRY 1

1. Dressler, Isidore and Rich, Barnett; Review Text in Eleventh Year Mathematics, New York, Amsco School Publications, Inc.; 1960.
(This is a more traditional approach. However, it is a good concise and brief review. Excellent resource for text items).

2. Johnson, Richard E.; McCoy, Neal H. and O'Neill, Ann F.; Introduction to Mathematical Analysis, New York, Holt, Rinehart, and Winston, Inc., 1962.
(Chapter 2 of this text is a good review for the teacher primarily. Many texts in Mathematical Analysis do have good precise reviews of Trigonometry).

3. Smith, Rolland R.; Lankford, Francis G., Jr. and Payne, Joseph N.; Contemporary Algebra, Book Two, Atlanta, Harcourt, Brace, and World, Inc., 1963.
(Chapter 14 of this text is not thorough in many elementary topics but does stress the practical side of trigonometry. Some very good practical problems).

4. Vanatta, Glenn D.; Carnahan, Walter D. and Fawcett, Harold P.; Advanced High School Mathematics, Columbus, Ohio, Charles E. Merrill Publishing Company, 1965.
(Chapters 4, 5, 6, 7, and 8 cover all the topics of Trigonometry 1 and 2. It is an easily read text).

5. Welchons, A. M.; Krickenberger, W. R. and Pearson, Helen R.; Modern Trigonometry, Atlanta, Ginn and Company, 1962.
(Many schools will have copies of this text since it was once a state adopted text. It could be used as resources and help a student as simply another approach to a topic).